TM 11-2050A

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OHMMETER ZM-21/U

DEPARTMENT OF THE ARMY • NOVEMBER 1954

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on
this equipment. 500 volts exist.

DON'T TAKE CHANCES

TECHNICAL MANUAL
No. 11-2050A

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *15 November 1954*

OHMMETER ZM-21/U

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Figure 1. Ohmmeter component of the ZM–21/U.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

This manual contains a description of Ohmmeter ZM-21/U, operating instructions, organizational maintenance information, theory of operation, repair of equipment, instructions for removing the equipment from service and repacking it for shipment or limited storage, and instruction for demolishing the equipment to prevent enemy use. These instructions apply only to Ohmmeter ZM-21/U.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army equipment:

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745-45-5 (Army); Navy Shipping Guide (Navy); Article 1850-4 (Navy); and AFR 71-4A (Air Force).

b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in SR 700-45-5.

c. DD Form 535, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700-45-5 and AFR 65-26.

d. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Description

a. Ohmmeter ZM-21/U (fig. 1) is a self-contained, portable, constant-voltage, insulation-resistance measuring set. The ohmmeter component consists of an ohmmeter of special design, a hand-operated, alternating-current (ac) generator, a selenium rectifier, and a resistance network housed in a bakelite case. Three terminals are provided for external connections (fig. 2). On top there is a handle and a hinged protective cover for the meter window glass. On the back are condensed instructions for operation.

b. The three test leads that are part of the ZM-21/U are 6 feet long with a spade clip at one end of each and a spring clip at the other.

The spring clips are covered with rubber covers; two covers are black and one is red.

c. The carrying case is a metal box, painted with gray enamel paint. It has a webbed carrying strap and two latches.

4. Application

a. Ohmmeter ZM–21/U is used to determine the insulation condition of telephone cables and wire lines between conductors of cables; between windings of transformers and between windings and ground; between windings and between windings and the frame of rotating equipment (motors, etc.) of all other types of electrical equipment of which insulation resistance is an important factor.

b. The ohmmeter applies a high potential to equipment under test. This will show low insulation resistance which may not read satisfactorily on an ohmmeter that uses 3 to 6 volts.

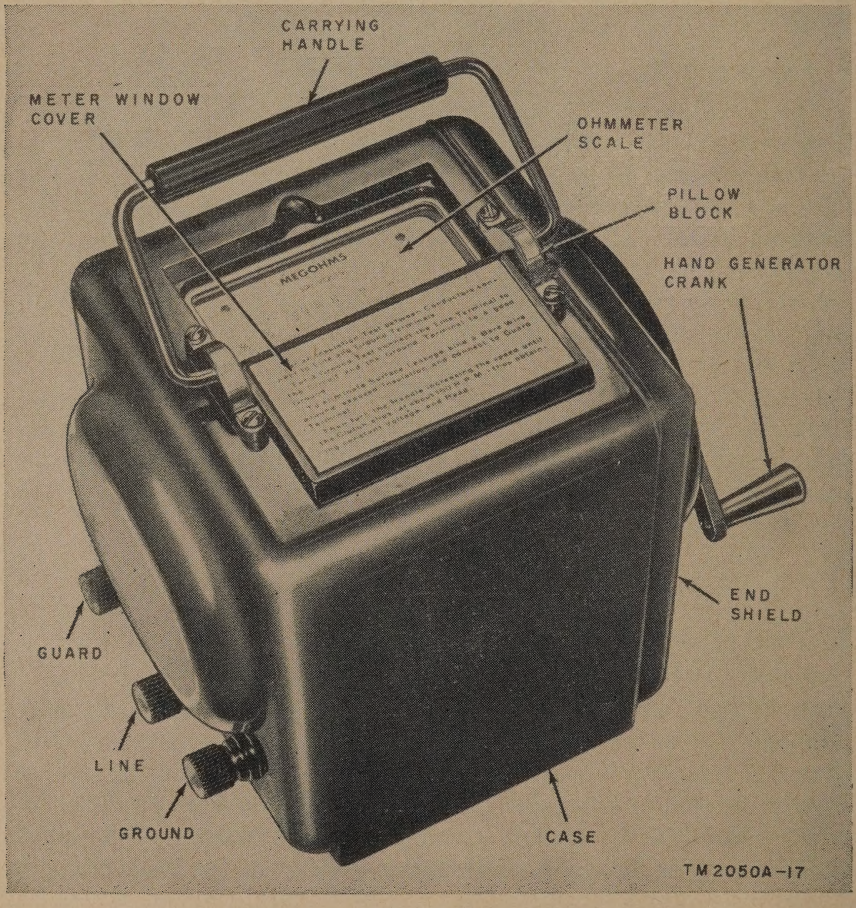

Figure 2. Ohmmeter, exterior view.

c. Regular use of Ohmmeter ZM-21/U can minimize failure in circuits or equipment caused by faulty insulation. A sudden lowering of insulation resistance indicates a fault that should be investigated immediately.

Caution: Do not use Ohmmeter ZM-21/U on equipment having an operating voltage of less than 500 volts. The potential applied may damage the equipment under test.

5. Technical Characteristics

Resistance range ..... 0 through 1,000 megohms.
Test potential ..... 500 volts dc ±5 percent (when measuring values below 2 megohms, the voltage drops materially) (fig. 19).
Accuracy ..... ±1 percent of any cardinal calibration point.

Note Insulation resistance above 1,000 megohms is indicated by a point marked INFINITY on the meter scale.

6. Table of Components

The following table gives the weights and dimensions of the ohmmeter, the carrying case, and Cords CD-478.

Quantity	Item	Dimensions (in.)			Weight (lb)	Volume (cu ft)
		Length	Height	Width		
1	Ohmmeter	7½	6	7¼	10.7	.2
1	Carrying case	10	7	8½	5.5	.34
2	Cord CD-478 (black)	72	------	------	.11	------
1	Cord CD-478 (red)	72	------	------	.11	------

Note This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

7. Packaging Data

Ohmmeter ZM-21/U may be packed for either domestic or oversea shipment (fig. 4).

a. Domestic Shipment. The ohmmeter is placed in its carrying case with the test leads and carrying strap in the test lead compartment. The cover is latched and the unit is cushioned with fiberboard pads and cells and placed in a close-fitting corrugated fiberboard box. The technical manuals are placed under the lid of the box, and the box is sealed with gummed tape. The box is 15 inches long, 10 inches wide, and 12 inches high. It weighs approximately 25 pounds and displaces 1.1 cubic feet.

b. Oversea Shipment. The ohmmeter is prepared for shipment as described in *a* above. The unit is then cushioned with fiberboard

pads and cells and placed in a corrugated box. Desiccant is placed in the cushioning cells and the box is sealed. The boxed unit is placed in a waterproof bag which is heat-sealed and inserted in a waterproof carton. The technical manuals are placed under the lid, and the carton is sealed with waterproof tape. One or several packaged sets may be placed in a wooden shipping container for oversea shipment. The wooden container is reinforced with flat metal straps. When only one set is packed, the package will be 17 inches long, 13 inches wide, and 15 inches high. It weighs approximately 30 pounds and displaces 1.9 cubic feet.

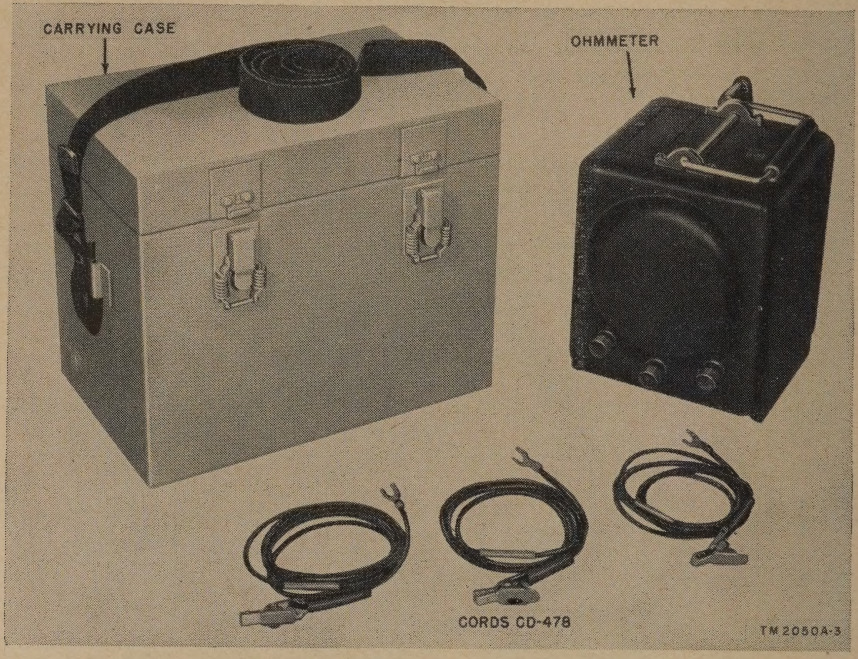

Figure 3. Ohmmeter, carrying case, and leads.

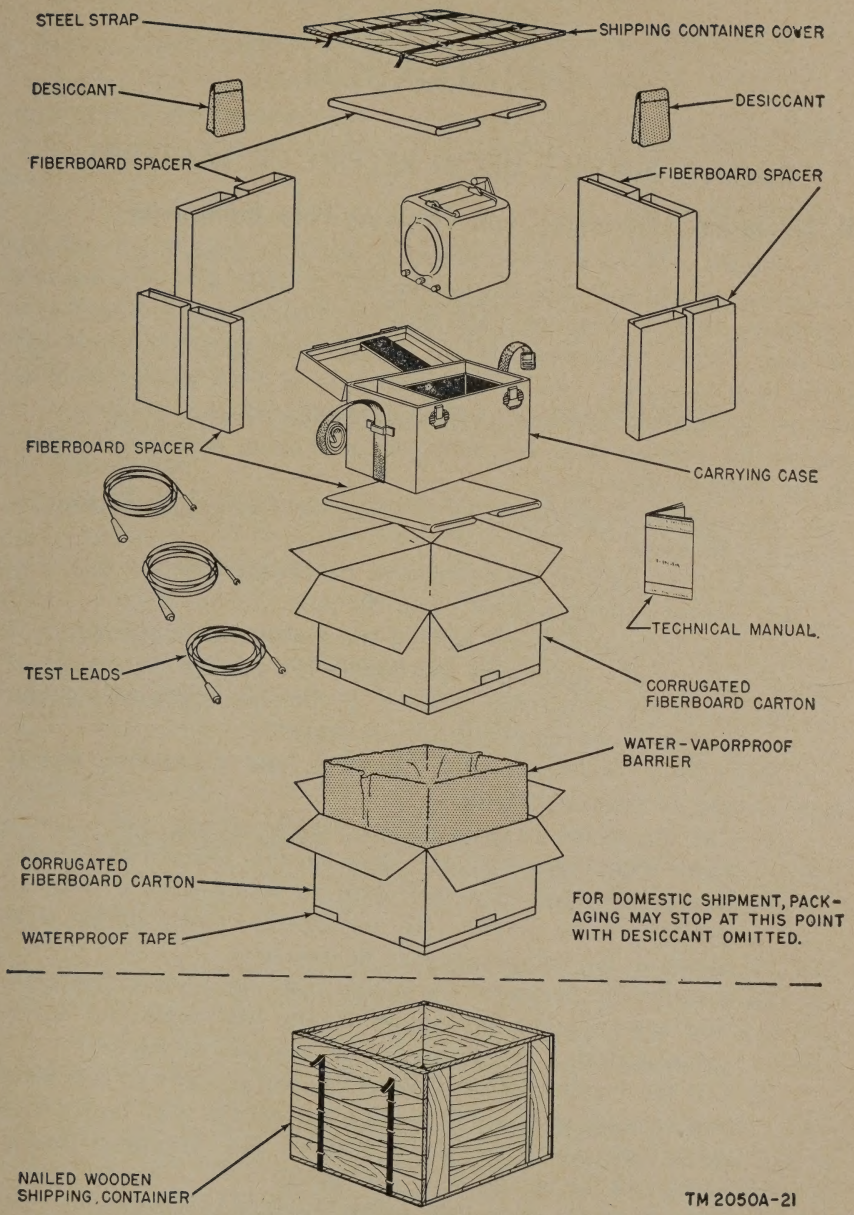

Figure 4. Packaging details for Ohmmeter ZM–21/U.

CHAPTER 2
INSTALLATION

Section I. SERVICE UPON RECEIPT OF MATERIEL

8. Uncrating, Unpacking, and Checking New Equipment

a. General. When new equipment is received, unpack it carefully in a location where it will not be exposed to dust, dirt, or excessive moisture. Avoid thrusting tools into the wooden box or fiberboard cartons. When unpacking, do not damage packaging materials any more than necessary. These materials may be used when repacking the equipment for storage or for shipment. If the equipment is packed for oversea shipment, store the packaging material carefully in the wooden container.

b. Step-by-step Instructions for Unpacking Equipment Packed for Domestic Shipment.

(1) Cut the seals of the corrugated fiberboard box.
(2) Remove the equipment from the box.
(3) Check the equipment against the shipping documents.
(4) Inspect the equipment thoroughly for damage.
(5) Place the cushioning material in the shipping container for future use in repacking the equipment.

c. Step-by-step Instructions for Uncrating and Unpacking Equipment Packed for Oversea Shipment.

(1) Cut the metal straps with a suitable cutting tool or twist them with pliers until the strap breaks; remove the straps.
(2) Remove the nails from the top of the wooden box with a nail puller; remove the top. Do not attempt to pry off the sides and top; the equipment may be damaged.
(3) Remove the packaged equipment from the wooden container and carefully cut the adhesive tape that seals the waterproof carton. Be careful not to damage the carton.
(4) Cut the barrier material along the top as close to the heat-sealed seam as possible so that the barrier may be resealed when required. Carefully remove the packaged equipment and the barrier from the carton.
(5) Cut the seals from the inner corrugated fiberboard box. Remove the paperboard cells which cushion the ohmmeter, and lift the ohmmeter, in its carrying case, from the box.
(6) Loosen the fastenings of the carrying case cover and open the cover. Remove the desiccant, and lift the ohmmeter from the carrying case.

(7) Place all the packaging material in the original container for use in repacking the equipment.
(8) Check the equipment against the shipping documents.
(9) Inspect the equipment carefully for damage.

9. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 8 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment against new equipment, if available. Look for tags or other indications pertaining to changes in the wiring of the equipment. If a change in wiring has been made, note the change on the schematic diagram. Be sure that no parts have been damaged.

c. Operate the ohmmeter in accordance with the procedures outlined in the equipment performance test (par. 42) to make sure that it is operating properly.

Section II. PREOPERATIONAL PROCEDURE

10. Installation

Ohmmeter ZM–21/U is used near the equipment or the wire or cable line to be tested. Remove the equipment from the carrying case and place it on a firm, level surface with the indicator scale in a horizontal plane. Do not place it in a strong, external, magnetic field such as is produced by some types of electrical equipment. Before operating the ohmmeter, ground it through the equipment under test by connecting the GROUND terminal on the side of the case to the equipment. Make this connection in accordance with instructions for the type of equipment under test. Unfold the crank to bring it into its operating position.

11. Preoperational Check of Ohmmeter

To be sure that there is no leakage between the test leads and at the same time to make a simple calibration check of the ohmmeter, proceed as follows:

a. Connect the spade terminals of the test leads to the LINE and GROUND terminals of the ohmmeter. Leave the other ends of the test leads disconnected. Turn the hand generator crank at operating speed (aprx. 160 revolutions per min. (rpm)). The ohmmeter pointer should indicate INFINITY.

b. With the spade terminals of the test leads connected to the LINE and GROUND terminals of the test set, short-circuit the clip ends of the test leads and operate the hand generator crank. The ohmmeter pointer should indicate ZERO.

c. If a further calibration check is desired and a resistor having a known value is available, connect the resistor to the test leads and operate the test set. The ohmmeter pointer should indicate the proper resistance value.

CHAPTER 3
OPERATION

Section I. OPERATION UNDER USUAL CONDITIONS

12. General

Make all tests with the hand generator crank rotated fast enough (aprx. 160 rpm) to cause the centrifugal clutch to engage. Since the ohmmeter scale is calibrated in megohms, the position of the pointer on the scale indicates insulation resistance values directly in megohms. Be careful to read the scale with the eyes directly above the pointer and the scale; otherwise, readings may be in error. The tests described in paragraphs 15 through 26 are necessarily general and cover equipment of all types and designs. Before testing any specific equipment, refer to the technical manual covering the equipment for definite insulation resistance standards.

13. Guard Connection

a. To obtain a true indication of the insulation resistance under test, both the insulation and the ohmmeter must be protected to eliminate possible errors due to surface leakage. The ohmmeter has an internal protective or guard system for this purpose. The guard system is connected to the GUARD terminal so that protection against surface leakage can be extended to the insulation under test. Figure 8 shows a cable under test with the guard connection in use. Any leakage current between the circuit under test and parallel circuits will be carried to the ohmmeter through the GUARD terminal, and the internal guard circuit of the test set will prevent this leakage current from entering the measuring circuit.

b. When guarded connections are used, meter readings indicate insulation resistance only and do not take into account the parallel shunting resistance of surface conditions. A measurement taken with a GUARD connection and compared to a measurement of the same equipment taken without a GUARD connection will establish whether low insulation resistance readings are caused by poor insulation or bad surface conditions. If readings taken with guarded connections are higher than those without guarded connections, the surface of the equipment has a comparatively low resistance.

14. Insulation Resistance

a. Unit of Measurement. Insulation resistance is that property of an insulating material which opposes the passage of electric current.

It is expressed in ohms or megohms. Insulation resistance increases as the thickness of the insulating material increases, but decreases as the area of the material under test increases. For example, if an insulating material covering a given surface and having a resistance of 100 meghoms is extended to 10 times its area, the insulation resistance will drop to 10 megohms. If the insulating material is doubled in thickness, however, the area having an insulation resistance of 100 megohms now will have a resistance of 200 megohms, and the area having an insulation resistance of 10 megohms will have a resistance of 20 megohms.

b. Conditions Affecting Insulation Resistance.

(1) *Temperature.* The temperature coefficient of the resistance of an insulating material is negative and numerically large. Therefore, even a small increase in temperature will cause a relatively large decrease in insulation resistance.

(2) *Moisture and humidity.* Chemically pure water is a nonconductor; however, the impurities that water absorbs from the atmosphere and the surfaces of equipment with which it comes in contact cause it to be partially conductive. Therefore, moisture will become a conductor in parallel with the insulation and cause a decided drop in insulation resistance. An insulation resistance drop caused by moisture is a temporary condition and can be remedied by drying out the equipment.

(3) *Chemical fumes.* Strong acid or alkali fumes, unlike water vapor, attack insulation and permanently lower its insulation resistance.

(4) *Surface conditions.* Dirt, especially when mixed with oil or with copper or carbon dust, forms a low-resistance path across the insulation, thus lowering its insulation resistance.

c. Expected Values of Insulation Resistance. As discussed in *b* above, insulation resistance is affected by varying conditions. Therefore, no set rules can be set up to govern its value. Certain minimum values have been established arbitrarily for different types of cable and equipment (par. 24). *Actual* values of insulation resistance, however, are not as important as *changes* in insulation resistance. Periodic insulation resistance tests of equipment should be made and the results recorded, together with information regarding climatic conditions at the time tests are made.

15. Insulation Test of Ac and Dc Rotating Machines Rated 600 Volts or Less

a. Connect a test lead from the LINE terminal of the ohmmeter to a lead, an exposed conductor, or to the commutator of the machine (fig. 5).

b. Connect another test lead from the GROUND terminal to the

shaft or frame of the equipment under test. Be sure that the surface to which the connection is made is free of paint or any other substance that is a nonconductor.

c. Turn the hand generator crank at operating speed. If the machine is cold, the reading should be between 1 and 10 megohms. If the machine is warm, the reading will be lower. Also a large machine will have a lower insulation resistance than a small machine.

d. If all circuits in the machine are not interconnected as in separately excited generators, measure each circuit individually.

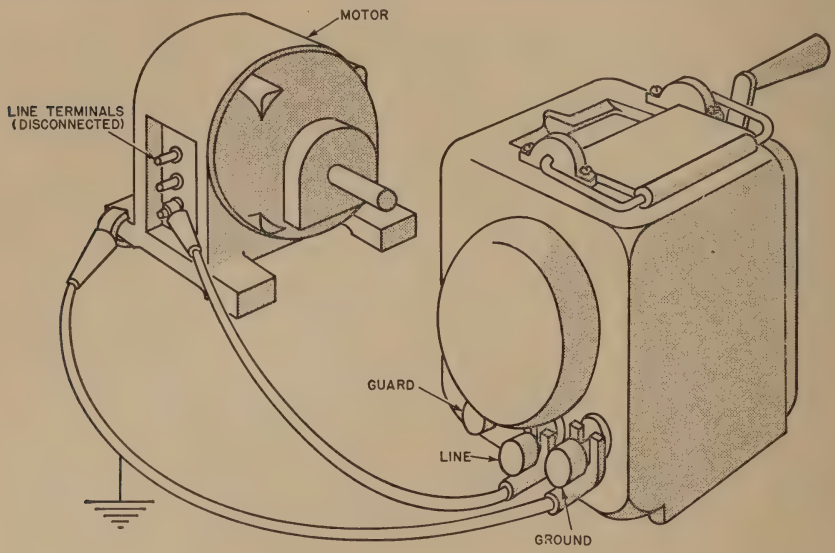

Figure 5. Connections for testing ac or dc rotating machines.

16. Insulation Test of Ac and Dc Rotating Machines Rated Over 600 Volts

a. Connect the equipment and test as directed for machines at 600 volts or less (par. 15*a* and *b*).

b. Turn the hand generator crank at operating speed. If the machine is cold, readings should range between 10 and 100 megohms. Readings will be lower if the equipment is warm.

c. Direct current (dc) fields on ac machines should read between 1 and 10 megohms.

17. Insulation Test of Transformers

a. Connect a test lead from the GROUND terminal of the ohmmeter to the core or case of the transformer (fig. 6).

b. Measure the high- and low-voltage windings separately. Connect a test lead from the LINE terminal of the ohmmeter, first to the low-voltage windings and then to the high-voltage windings.

c. Measure between windings by connecting the GROUND lead from the volt ohmmeter to one winding of the transformer, and another test lead from the LINE terminal of the ohmmeter to the other winding.

d. Turn the hand generator crank at operating speed. Readings for all measurements should be 100 megohms or more on air core transformers. Readings on oil-filled transformers will be considerably lower. Extremely low readings indicate the presence of moisture in the oil and indicate that the oil should be changed.

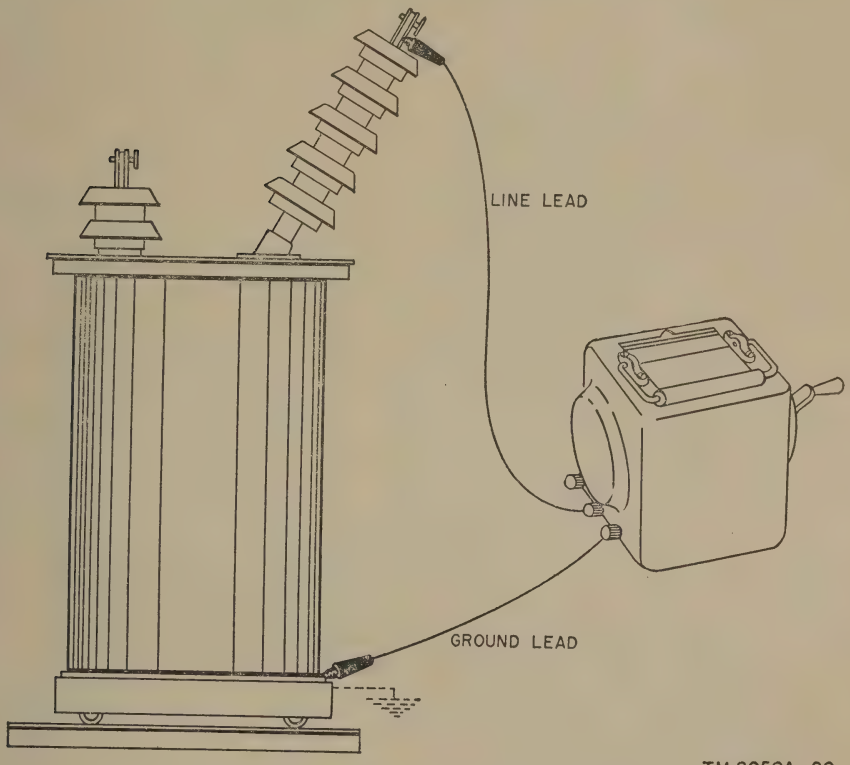

Figure 6. Connections for testing transformers.

18. Insulation Test of Capacitors

a. Connect a test lead from the GROUND terminal of the ohmmeter to the case of the capacitor (fig. 7).

b. Connect another lead from the LINE terminal of the ohmmeter to one of the terminals of the capacitor.

c. Turn the hand generator at operating speed. The reading obtained is the insulation between the capacitor and its case. The reading should be 500 megohms or more.

d. Remove the GROUND lead from the case of the capacitor and connect it to the other terminal of the capacitor.

e. Turn the crank handle at the operating speed. The ohmmeter pointer will dip toward ZERO when the generator crank is first turned, but will move up the scale as the capacitor becomes charged with the test potential. The capacitor must be fully charged with the test potential before a reading will be indicated. Turn the generator crank for 1 minute before taking a reading. The insulation reading should be 500 megohms or more.

Caution: Discharge the capacitor after an insulation resistance test has been made, or disconnect the leads one at a time. Short-out the capacitor. Contact with a fully charged capacitor can cause a dangerous shock.

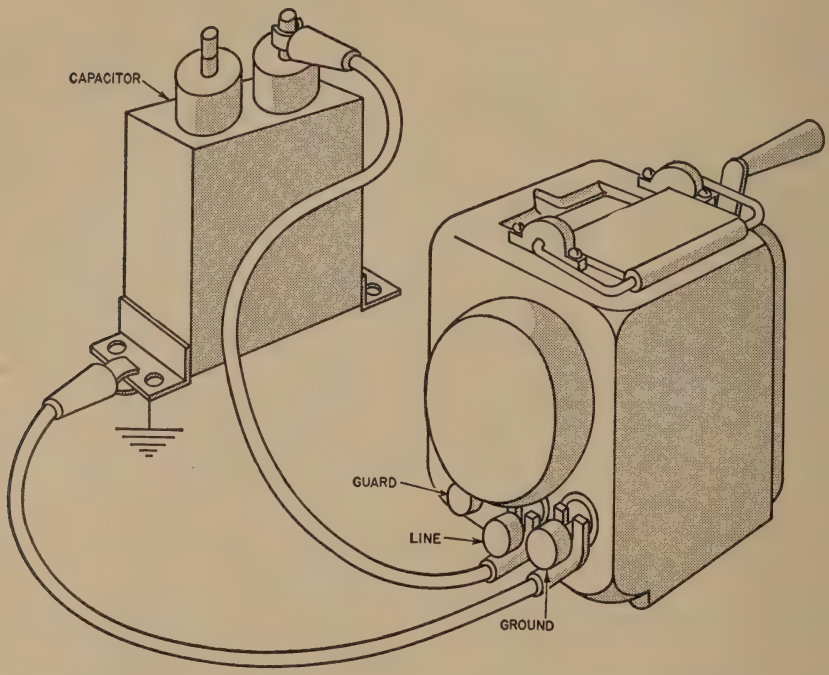

Figure 7. Connections for testing capacitors.

19. Insulation Test of Power Cables and Wires

Note. Disconnect equipment from the power line while insulation resistance measurements are being made.

a. Power Cables.

(1) *Connections for measurement of one conductor to all other conductors.*

(*a*) Connect a test lead from the LINE terminal of the ohmmeter to the conductor to be measured (fig. 8).

(*b*) Tie all other conductors together and connect them to the GROUND terminal of the ohmmeter.

(*c*) Connect a test lead from the GUARD terminal of the ohmmeter to the cable sheath. Use of this terminal prevents error caused by parallel ground leakage.

(2) *Connections for measurement of one conductor to ground.*

(*a*) Connect a test lead from the LINE terminal of the ohmmeter to the conductor to be measured (fig. 9).

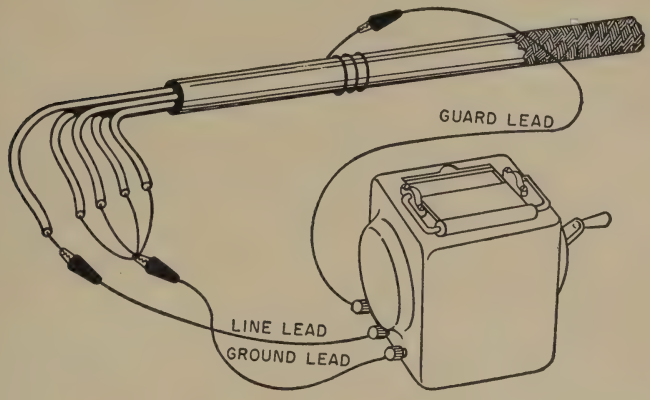

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Figure 8. Connections for measuring one cable conductor to all other conductors.

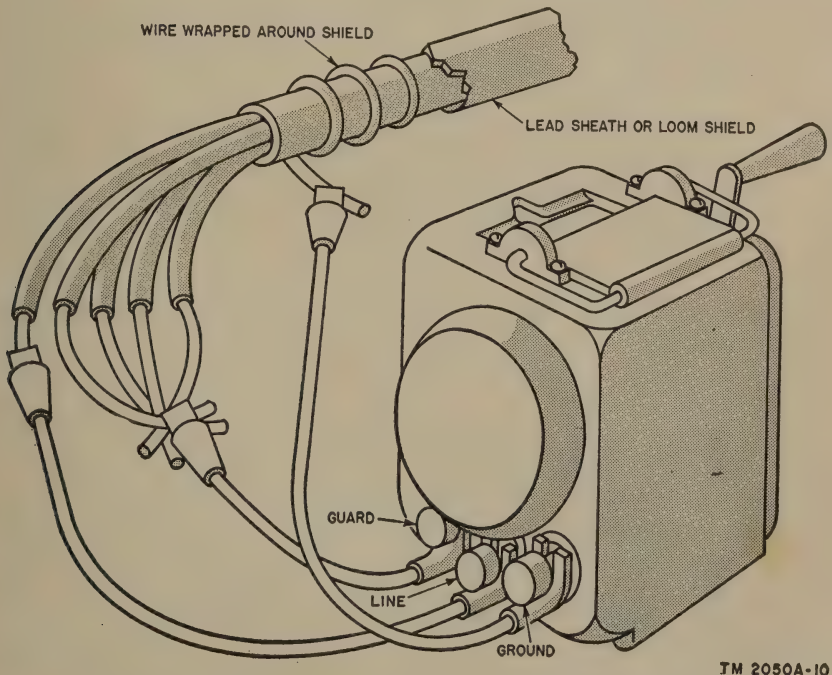

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Figure 9. Connections for measuring one cable conductor to ground.

(*b*) Connect a test lead from the GROUND terminal to the shield of the cable

(*c*) Tie all other conductors together and connect them to the GUARD terminal. Use of the GUARD terminal prevents error caused by leakage in the parallel circuits.

(3) *Operation.*

(*a*) Turn the hand generator crank at operating speed. A short length of cable will generally have an insulation resistance of 1,000 megohms or more. The insulation resistance of a long cable will be considerably lower than that of a short cable.

Note. When testing the insulation of a long cable, operate the hand generator for 1 minute or more before taking a reading. This will eliminate any error that might be caused by the electrostatic capacity of the cable.

(*b*) After all measurements have been made, discharge the cable by grounding all the conductors.

b. Power Wires. Test the insulation of individual power wires in the same manner as cable conductors (*a*(1) above). Make the GROUND connection to the outer sheath or jacket of the wire.

20. Insulation Test of Telephone Cables and Wires and Minimum Insulation Resistance Values

a. Testing Insulation Resistance.

(1) Test the insulation of exchange cables in the same manner as power cables (par. 19*a*). The conductors of these cables, when new, should have an insulation resistance of at least 500 megohm-miles.

Note. A conductor is said to have an insulation resistance of 500 megohm-miles when a 1-mile length has an insulation resistance of 500 megohms. Since a short length of cable has a higher resistance than a long length, a 10-mile length will have an insulation resistance of 50 megohms, and a 100-mile length will have an insulation resistance of 5 megohms, etc.

(2) When testing the insulation resistance of large exchange cables, divide the pairs into bunches of 25 and 100 pairs per bunch. Test each bunch as a single conductor of a power cable.

(3) If the insulation resistance of a bunch is as high or higher than a single pair, assume that the insulation resistance of all pairs in that bunch is satisfactory.

(4) Test each bunch in a cable separately. If the insulation resistance of a bunch is less than that given in the table (*b* below), separate the wires in the bunch and measure each wire separately against all other wires grounded to the sheath. Each wire should give a reading as high as that given in the table.

(5) If the insulation resistance of any individual wire is less than that given in the table, disconnect all other bunches from the sheath and measure the wire against these bunches and against the sheath. This will determine if the trouble is between wires, or between the wire and the sheath, or both.

(6) After testing all the bunches, measure a few wires of each bunch against the remaining wires of the bunch to determine whether any of the conductors have a low insulation resistance.

b. Insulation Resistance Requirements for Telephone Cables. The table below gives the insulation resistance requirements for telephone cables of various lengths. These figures are based on the requirements of an insulation resistance of 500 megohms per mile of cable. They are the minimum insulation between one wire and the sheath, with all other wires of the cable grounded to the sheath at a temperature of 60° F.

Note. Operate the set for 1 minute before taking a reading.

Length of cable (ft)	Required insulation resistance (meg)	Length of cable (mi)	Required insulation resistance (meg)
500	5, 280	1	500
1,000	2, 640	2	250
1,500	1, 760	3	167
2,000	1, 230	4	125
3,000	880	5	100
4,000	660	6	88. 3
5,000	528	7	71. 3
6,000	440	8	62. 5
7,000	377	9	55. 5
8,000	330	10	50
9,000	293	11	45. 4
10,000	264	12	41. 7
		15	33
		20	25
		25	20
		50	10

c. Insulation Resistance Requirements for Spiral-Four Cable.

(1) *General.* Spiral-four cable consists of four individually insulated conductors in a braided metal sheath. Cable WC–548 has a heavy rubber jacket; Cable WF–8/G has a polyethylene plastic covering. For a complete test of the insulation resistance of spiral-four cable, measure each conductor in turn with the other three conductors connected to the braid. Thus a complete test can be made in four measurements.

(2) *Cable WC–548.*

(*a*) Insulation resistance requirements for various lengths of new Cable WC–548 are as follows:

Cable length (mi)	Insulation resistance (meg)
¼	750
1	200
25	10

(*b*) In the case of a working cable, the insulation resistance of one ¼-mile Cable Assembly CC–358 should not drop below 10 megohms, and the insulation resistance of a 25- to 30-mile repeater section should not drop below 1 megohm.

(3) *Cable WF–8/G.*

(*a*) New Cable WF–8/G, either in ¼-mile lengths of Cable Assembly CX–1065/G or four cables coupled together during initial installation, should show an insulation resistance above 1,000 megohms. For lengths greater than 1 mile, the minimum insulation resistance can be found by dividing 1,000 by the number of miles in the cable. For example, if a 10-mile length of Cable WF–8/G is to be tested: 1,000÷10=100 megohms, the minimum resistance for 10 miles.

Note. Manufacturing specifications require a minimum resistance of 5,000 megohms per 1,000 ft. Insulation resistance above 1,000 megohms is indicated by INFINITY on the meter scale of the ohmmeter.

(*b*) A cable line may develop low insulation resistance and deteriorate to a point where it can no longer be useful. No matter what length of line is involved, either loaded or nonloaded, locate and remove the cause when the insulation resistance falls below 1 megohm.

d. Computing Minimum Insulation Resistance of Cable. The minimum insulation resistance for any length or size of cable can be found as follows:

(1) The required minimum insulation resistance between one wire 1 foot long and the cable sheath is 2,640,000 megohms. To find the required minimum insulation resistance for one insulated conductor of any length, divide 2,640,000 by the length of the conductor expressed in feet. For example, to find the required insulation resistance between one conductor and the cable sheath of a cable 672 feet long:

2,640,000÷672=3,928.57 megohms.

(2) If the cable is a multiple-pair cable and if it is necessary to find the minimum insulation resistance of the entire cable to the cable sheath, divide the requirement for one conductor by the total number of conductors in the cable. In the case of a 51-pair cable, the total number of conductors would be 51 × 2 or 102 conductors. Thus, to find the minimum insulation resistance requirement for a 51-pair cable 672 feet long (subpar. (1) above):

3,928.57÷102=38.51 megohms.

21. Insulation Test of Wiring Installations

Wiring systems are tested to see if they are free of short circuits and grounds. Remove fuses and open switches before making tests.

a. Testing for Grounds.

(1) Connect the GROUND terminal of the ohmmeter to a good ground.

(2) Connect the line terminal to a wire of the wiring system under test. Measure one wire at a time. A low reading indicates that a wire is grounded. A high reading indicates that the insulation is good.

b. Testing for Short Circuits.

(1) Connect the LINE terminal to one wire of the system.

(2) Connect the GROUND terminal to the other wire.

(3) Wire circuits of #12 or #14 AWG wire should have an insulation resistance of approximately 1 megohm. The insulation resistance of wires of a larger gage is based on current capacity and should read approximately as follows:

Current capacity (amperes)	Insulation resistance (ohms)
25 through 50	250, 000
51 through 100	100, 000

Note. Circuits with a current capacity above 100 amperes cannot be measured on Ohmmeter ZM–21/U. The lowest calibration point of the ohmmeter is 100,000 ohms (.1 megohm).

22. Insulation Tests of Miscellaneous Units

a. When the circuit is designed to carry only voltage, the insulation resistance of the wiring of various electronic meters should be no lower than 20 megohms. If the circuit is designed to carry current, the minimum resistance should be 5 megohms.

b. The insulation resistance of tools and appliances should have the same insulation resistance as the equipment to which they are attached.

23. Resistance of Resistors

The resistance of resistors can be found with Ohmmeter ZM–21/U if they are in the megohm range. Connect the LINE terminal to one side of the resistor, and connect the GROUND terminal to the other; operate the ohmmeter. The reading will be directly in megohms.

Note. Be sure that the resistor is disconnected from its circuit and that all power is turned off.

24. General Insulation Resistance Values of Certain Types of Equipment

Whenever possible, take minimum insulation resistance values of equipment being tested from the specifications covering such equipment. If specifications are not available, however, use the following table as a guide. This table consists of accepted minimum requirements.

Type of equipment	Type of test	Insulation resistance
Multiple conductor cables, such as those used for interconnecting various parts of radio equipment. (Make tests with plugs, jacks, and other fittings attached).	Between single conductor and shield.	100 to 1,000 megohms.
	Conductor to all other conductors.	100 to 500 megohms.
Complete power circuits.	Conductor to conductor or conductor to ground.	Circuits carrying 5 to 50 amperes, .2 to 2 megohms. Circuits carrying 100 amperes or over, .1 to 1 megohm.
Rotating equipment	Between ground and all circuits of equal potential above ground connected together.	Minimum insulation resistance (in megohms) $= \frac{\text{Rated voltage of equipment}}{\text{Kva (or kw) rating} + 1{,}000}$
Transformers, chokes, and similar apparatus.	Winding to winding or winding to frame.	Minimum insulation resistance (in megohms) $= \frac{\text{Rated voltage of equipment}}{\text{Kva (or kw) rating} + 1{,}000}$
Ammeters, voltmeters, wattmeters, etc.	Between all circuits in case to ground.	At least 20 megohms.
	Between different circuits.	At least 5 megohms.

25. Locating Low Insulation

a. General. Ohmmeter ZM–21/U may be used in locating low cable insulation caused by moisture. Often in a fault of this type

the moisture will dry out, thus restoring the insulation to full effectiveness and clearing the trouble before the trouble can be located. Such a trouble can be *burned in* by applying high voltage directly across the fault. This breaks down the insulation at the fault and permits the bare wires to make metallic contact. When a solid ground or short circuit has been developed, the fault can be located by a Wheatstone bridge test set or by using tone and an exploring coil.

b. Procedure. To burn in trouble using Ohmmeter ZM–21/U, proceed as follows:

(1) Connect the wire under test to the GUARD terminal of the test set.

(2) Connect the cable sheath to the GROUND terminal.

(3) Turn the hand generator crank at operating speed. Full generator voltage (500 volts) is applied directly across the fault without the presence of the current ballast resistance in the circuit. There will be no reading on the ohmmeter scale.

26. Stopping Procedure

When measurements have been completed, disconnect all test leads from the ohmmeter and from the apparatus being tested. Close the hinged cover on top. Place the ohmmeter and leads in the carrying case.

Section II. OPERATION UNDER UNUSUAL CONDITIONS

27. General

When operating Ohmmeter ZM–21/U in regions where sand, heat, cold, humidity, or moisture prevail, special precautions must be taken to keep the instrument in operating condition. Paragraphs 28, 29 and 30 contain instructions for minimizing the effects of these unusual conditions.

28. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient operation of the equipment. Instructions and precautions for operation under such adverse conditions follow:

a. Handle the equipment carefully.

b. Keep the equipment warm and dry. Locate the equipment inside a heated inclosure where there is no danger of a cold draft.

c. When cold equipment is brought into a warm, moist room, it will collect moisture. When the equipment reaches room temperature, dry it thoroughly.

29. Operation in Tropical Climates

When operated in tropical climates, Ohmmeter ZM–21/U may be installed in tents, huts, or, when necessary, in underground dugouts.

When equipment is located below ground and when it is used in swampy areas, moisture conditions are more acute. Ventilation is usually very poor, and the high relative humidity causes condensation or moisture on the equipment whenever the temperature of the equipment drops lower than the ambient air. To minimize this condition, use a heater or lighted electric bulbs near the equipment.

30. Operation in Desert Climates

Conditions similar to those encountered in tropical climates often prevail in desert areas. Use the same measures (par. 29) to insure proper operation of the equipment.

a. The main problem which arises with operation of the test set in desert areas is the large amount of sand, dust, and dirt which may enter the equipment. The ideal preventive precaution is to house the equipment in a dustproof shelter. Since, however, such a building is seldom available and would require air conditioning, the next best precaution is to make the building in which the equipment is used as dustproof as possible, using available materials.

b. Use care to keep the equipment clean and as free from dust as possible. Excessive amounts of dust, sand, or dirt that come into contact with oil and grease result in grit, which will damage the equipment.

c. A drastic fall in temperature at night often causes condensation. To prevent this, cover the equipment with tarpaulin or a similar covering material.

CHAPTER 4
ORGANIZATIONAL MAINTENANCE

Section I. ORGANIZATIONAL EQUIPMENT

31. General

Before starting preventive maintenance procedures, have available all materials needed to perform the operations in the preventive maintenance check list (par. 35). These materials may be obtained through the regular supply channels.

32. Materials

Materials for organizational maintenance operations are listed below:

Sig C stock No.	Name and description of item	Used to
6Z7500–000	Abrasive, sheet: sandpaper; No. 000; 9″ x 12″ sheets.	Remove rust and corrosion from metal parts.
CE supply No. 38–3706.400–130[a].	Brush, paint: soft hair; flat; 1″ wide.	Remove dust and dirt from scale aperture, from between binding posts, and from interior of carrying case.
CC supply No. 122585[b]	Carbon tetrachloride	Remove gummy deposits from test lead clips, terminals, and binding post contact surfaces.
6G236.2	Cleaning compound	Remove grease, oil, and corrosion from equipment.
6Z1989	Cloth, textile: cheesecloth; lint free; 36″ wide.	Clean various parts of equipment.
6Z7360	Stick, orange	Remove fungus growth from equipment.
6N8583	Tape TL–83: friction; ¾″ wide.	Repair test lead insulation.
6G202.11	Rubber cement	Cement loose rubber cushions in carrying case.

[a]Corps of Engineers stock number. [b]Chemical Corps stock number.

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

Section II. PREVENTIVE MAINTENANCE

33. General

a. Meaning and Purpose of Preventive Maintenance. Preventive maintenance is a series of systematic operations performed on equipment at regular intervals. It consists of inspections and services designed to keep the equipment in good operating condition. The primary purpose of preventive maintenance is to prevent failures and breakdowns that necessitate major repairs. For information on organizational, field, and base maintenance, see AR 750–5, Maintenance Responsibilities and Shop Operation.

b. Use of Preventive Maintenance Forms (figs. 10 and 11).

(1) The decision as to which items on DA Forms 11–238 and 11–239 are applicable to this equipment is a tactical decision to be made in the case of first echelon maintenance by the communications officer/chief or his designated representative, and in the case of second and third echelon maintenance, by the individual making the inspection. Instructions for the use of each form appear on the reverse side of each form.

(2) Circled items in figures 10 and 11 are partially or totally applicable to the ZM–21/U. References in the item column refer to paragraphs in text which contain additional maintenance information.

34. General Preventive Maintenance Techniques

a. Use No. 000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) If necessary, except for electrical contacts, moisten the cloth or brush with solvent (SD); after cleaning, wipe the parts dry with a cloth.

(2) Clean electrical contacts with a cloth moistened in carbon tetrachloride and then wipe them dry with a dry cloth.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from difficult places.

Caution: Be careful not to direct the air blast toward the meter movement.

35. Performing Preventive Maintenance

The following check list shows the operator how to maintain the equipment so that troubleshooting and repair can be reduced to a minimum. The list shows what, when, and how to check, and precautions to be taken before, during, and after checking the equipment.

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE: OHMMETER ZM-21/U

EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
(1)	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR. 35 (1)							
(2)	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 10							
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.							
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.							
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.							
(6)	CHECK FOR NORMAL OPERATION. PAR. 42							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.		13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
(8)	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 35 (4)		(14)	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 35 (1)	
(9)	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 35 (2)		(15)	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 35 (1)	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.		18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM 2050A-30

Figure 10. DA Form 11–238.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.
OHMMETER ZM-21/U	

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	COND.	NO.	ITEM	COND.
(1)	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (*receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories*). PAR. 35		19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS; INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES.	
(2)	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 10		20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.	
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.		21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION.	
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.		22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.		23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.	
(6)	CHECK FOR NORMAL OPERATION. PAR. 42		24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE.	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.		25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS.	
(8)	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 35(4)		26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE.	
(9)	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 35(2)		27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS.	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		28	CHECK SETTINGS OF ADJUSTABLE RELAYS.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.		30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.	
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.		31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS.	
(14)	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 35(1)		32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE.	
(15)	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 35(1)		33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.		34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.		35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.		(36)	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS. PAR. 35(1)	
			37	MOISTURE AND FUNGIPROOF.	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE. 68—10—64362-1

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Figure 11. DA Form DA–239.

Item No.	What to check	When to check*	How to check	Precautions
1	Exterior of unit.	W	Inspect for damaged places, dirt, dust, grease, rust, corrosion, fungus, and loose or missing screws. Tighten all loose screws and replace any that are missing. Clean the exterior of the bakelite case and the glass protecting the ohmmeter scale with a lint-free cloth moistened with carbon tetrachloride. Use a cloth slightly moistened with solvent (SD) to remove dirt, oil, or corrosion. Remove corrosion which cannot be removed with solvent (SD) with No. 000 sandpaper and wipe dry with a dry cloth. If fungus growth is present, be sure that the equipment is thoroughly dry before brushing it off. Remove heavy fungus growth with an orange stick and wipe the unit with a clean cloth moistened with solvent (SD).	Do not tighten screws carelessly. Screws tightened beyond the pressure for which they are designed may be damaged or broken. After cleaning with solvent (SD), dry the equipment thoroughly. The cleaning fluid may cause leakage between terminals.
2	Test leads	W	Inspect for loose test clips and terminals and for dust, dirt, grease, and corrosion on the insulation and on the terminations. Use a cloth slightly moistened with solvent (SD) to clean leads and terminals. Check leads for breaks in the rubber jacket. If breaks are found, repair by covering with friction tape.	When it is necessary to tape leads, be sure that enough tape is used to insure good insulation.
3	Interior of unit.	M	Carefully remove the mechanism from the bakelite case by removing the four screws holding the end shield and by withdrawing the end shield and attached chassis from the case. Inspect for loose or missing	Tighten screws and nuts securely but do not overtighten. Be careful not to break connections or damage wiring. Do not get solvent (SD) on insulators.

*W—Weekly; M—monthly.

Item No.	What to check	When to check*	How to check	Precautions
	Interior of unit—Con.		mounting screws, dirt, corrosion, loose connections at apparatus terminals, broken wiring, and defective insulation. Check the rectifier and capacitor for dirt and corrosion. Tighten loose mounting screws and nuts. Tape leads having defective insulation. Clean dirt and dust from the apparatus and wiring with a soft bristle brush. Wipe accessible parts with a clean, dry cloth. Remove corrosion with a clean cloth moistened with solvent (SD), and use No. 000 sandpaper to loosen corrosion that cannot be removed with solvent. Inspect all resistors for blistering, discoloration, and other evidence of overheating.	Never use a damp or wet cloth to clean wiring.
4	Carrying case.	M	Inspect for chipped paint, dirt, dust, grease, corrosion, and fungus. Wipe out the interior of the case with a dry cloth and remove dirt adhering to the case with a cloth dampened with solvent (SD). Loosen corrosion that cannot be removed with solvent (SD) with No. 000 sandpaper. Examine the sponge rubber case lining. If the lining is loose in any place, fasten it with rubber cement. Check the carrying strap for worn or frayed places, broken or defective buckle parts, and broken or rotted threads in the buckle stitching.	

*W—Weekly; M—monthly.

Section III. WEATHERPROOFING

36. General

Signal Corps equipment, when operated under severe climatic conditions (found in tropical, arctic, and desert regions) requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

37. Tropical Maintenance

A special moistureproofing and fungiproofing treatment has been devised that provides a reasonable degree of protection. This treatment is explained fully in TB SIG 13 and TB SIG 72. The equipment has been moistureproofed and fungiproofed, and it is necessary to use this treatment only when parts are repaired or replaced.

38. Arctic Maintenance

Special precautions are necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures. These precautions are fully explained in TB SIG 66 and TB SIG 219.

39. Desert Maintenance

Special precautions are necessary to prevent equipment failure in areas subject to extremely high temperature, low humidity, and excessive sand and dust. These precautions are fully explained in TB SIG 75.

Section IV. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

40. General

The troubleshooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) is limited in scope by tools, test equipment, and replaceable parts available and by the existing tactical situation. With the exception of replacing or repairing defective test leads, troubleshooting by the operator consists of reporting symptoms of trouble to a qualified repairman.

41. Visual Inspection

If the ohmmeter fails to operate properly, inspect the equipment for the following faults before beginning a detailed examination (par. 42):

a. Test leads for proper connection.

b. Test leads for wear, breaks, and disconnection.

42. Equipment Performance Test

a. If visual inspection fails to show any apparent defect in the test leads, test the ohmmeter for full scale deflection, and ZERO reading. Follow the procedures in paragraph 11.

b. Test the equipment with the line and ground leads connected to a resistor of known value.

c. If the pointer fails to move to INFINITY or ZERO or to indicate the proper resistance value on the meter scale, turn the equipment over to depot maintenance personnel for complete troubleshooting and repair (pars. 53 through 67).

CHAPTER 5
THEORY

43. General

(fig. 12)

Ohmmeter ZM–21/U is designed to measure high values of insulation resistance of all types of electrical equipment and wiring. The ohmmeter operates from a self-contained power supply that consists of a hand generator, a transformer, a rectifier, and a filter capacitor. The mechanism that drives the generator is connected to the generator through a centrifugal clutch which disengages when rotated at a speed in excess of 160 rpm. Constant voltage is therefore maintained. The resistance range of the ohmmeter is from 0 through 1,000 megohms. The resistance is indicated by a meter of special design, and the indication given is as near as possible to a true representation of the insulation resistance of the equipment, wire, or cable under test.

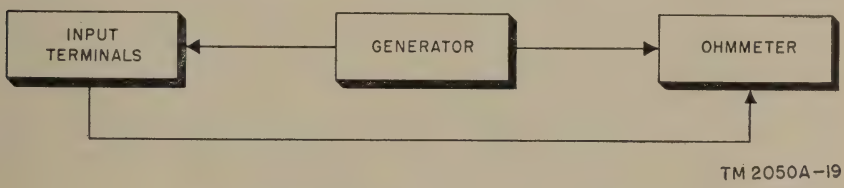

Figure 12. Ohmmeter ZM–21/U, block diagram.

44. Power Supply

a. Hand Generator.

(1) The ac hand generator consists of an armature that is rotated in a fixed magnetic field. The output is taken from the generator slip rings by carbon brushes. The output of the generator is .15 volt at 1,750 rpm, and the frequency is 700 cycles per second (cps).

(2) The generator drive assembly is driven by a hand operated crank through a gear train and a clutch assembly. When the crank reaches an operating speed of 160 rpm, centrifugal force disengages the clutch shoes from the shaft hub. Even though the crank may be operated at speeds in excess of 160 rpm, constant voltage will be delivered from the generator.

b. Transformer. Transformer T1 (fig. 18) is a step-up transformer with a turns ratio of approximately 1 to 3,333.3 and a current rating

of 6 milliamperes (ma). The generator is connected to the primary of the transformer. The output of the transformer is 500 volts. The secondary is connected to ground and to a halfwave rectifier.

c. Rectifier. The ac output of the transformer is rectified by a selenium rectifier. The pulsating dc is filtered by a capacitor.

d. Capacitor. A .05 microfarad (μf) capacitor is connected between the positive side of rectifier CR1 and ground (fig. 14). It acts as a filter for the pulsating dc output of the rectifier. The output will be a sufficiently smooth dc for meter operation.

45. Resistance Network

The resistance network consists of four 500,000-ohm resistors (R1, R2, R3, and R4) connected in series (fig. 14). The 2-megohm resistance is connected in series with coil L2 of the meter and the positive side of the power supply to limit the flow of current through L2.

46. Meter Movement

The meter used in Ohmmeter ZM–21/U (fig. 13) is a true ohmmeter. The indicating instrument consists of two coils: potential coil L2 and current coil L1, which are designed and connected to oppose each other in a definite ratio. The indicating pointer is rigidly fixed to the coil assembly, and when the meter movement is connected through a proper resistance network to the generator and test set terminals, it will indicate the true resistance of the apparatus under test. The coil and pointer assembly is supported by two bifilar suspensions (AA and BB, fig. 13) and rotates around a stationary soft iron core. Current flows to the indicator through these same suspensions instead of through the conventional springs found in other types of indicating instruments. This construction permits the moving system to move freely over the scale so that the indication shown will be as close as possible to a true representation of resistance without regard to fluctuation of voltage in the circuit. The moving system rotates in a magnetic field between the two pole pieces (N and S) of a permanent magnet.

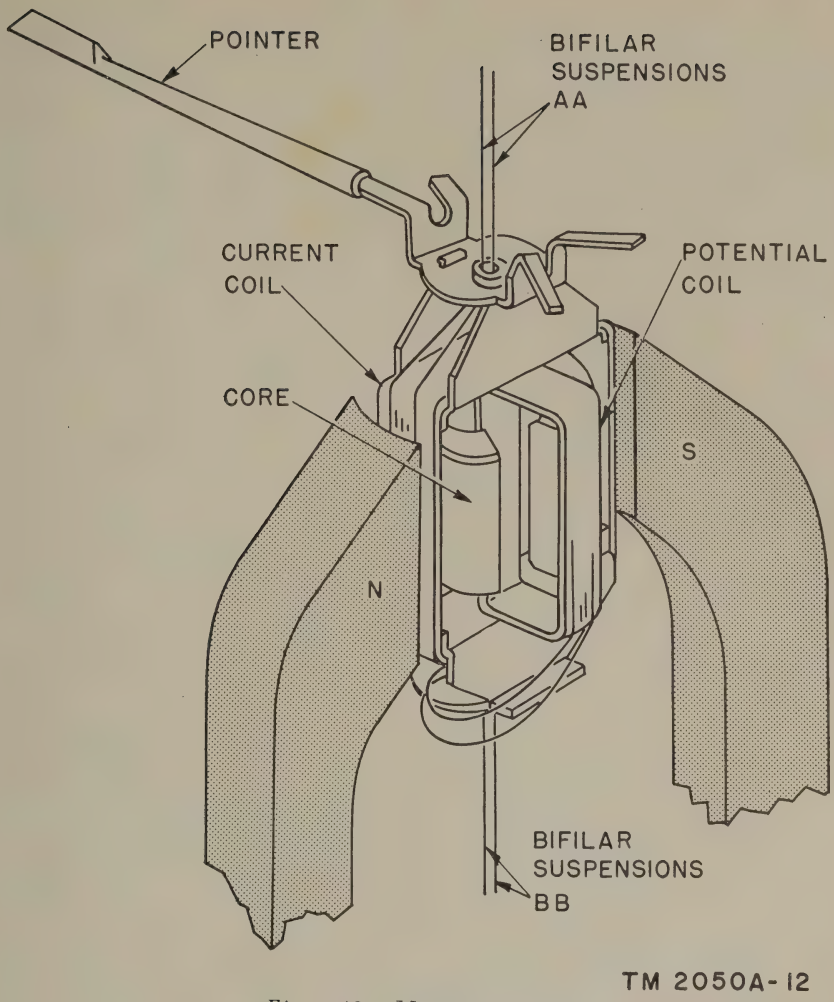

Figure 13. Meter movement.

47. Working Circuit

a. The working circuit, shown in heavy lines in figure 14, is one of three interconnected electrical circuits. Part of the current flows from the ac generator G1 and transformer T1 combination to the GROUND terminal (positive side), through the unknown resistance to the LINE terminal, through current coil L1, through rectifier CR1, and back to the generator unit. The current flowing through current coil L1 tends to rotate the coil and pointer assembly in a clockwise direction. The other part of the current flows from the transformer generator unit through four 500,000-ohm resistors R1 through R4, potential coil L2, rectifier CR1, and back to the generator unit. The current flowing through potential coil L2 tends to rotate the coil and pointer assembly in a counterclockwise direction.

b. With nothing (infinite resistance) connected across LINE terminal E2 and GROUND terminal E1, all of the generator current will flow through potential coil L2 and move the pointer to INFINITY on the scale. With GROUND terminal E1 and LINE terminal E2 short-circuited (zero resistance), practically all of the current will flow through current coil L1 and move the pointer toward ZERO on the scale. Therefore, as the resistance between GROUND and LINE terminals increases from zero to infinity, the pointer will move from ZERO to INFINITY on the scale.

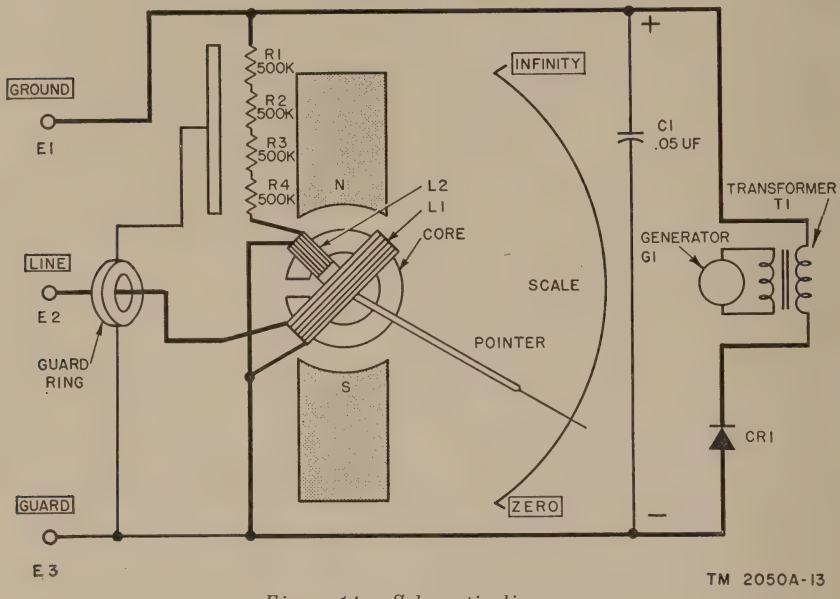

Figure 14. Schematic diagram.

48. Guard Circuit

a. Paragraph 46 explains how resistance between GROUND terminal E1 and LINE terminal E2 controls the position of the pointer on the scale. Since a certain amount of surface leakage exists across the bakelite case between these terminals, current through this leakage path will affect the readings of the instrument unless protection is provided. The guard circuit, shown in light lines in figure 15, provides this protection. Leakage current that may flow from GROUND terminal E1 to the LINE terminal E2 is picked up by the guard ring and led directly to the generator. Leakage current prefers this path of a lower resistance to that of current coil L1.

b. Resistors R1, R2, R3, and R4 are mounted on, but insulated from, metal plates which are connected to the guard ring. The metal plates perform the same function with regard to these resistors as the guard ring performs with regard to LINE terminal E2. The entire guard system is connected to GUARD terminal E3 and, thus, can be connected to the apparatus under test.

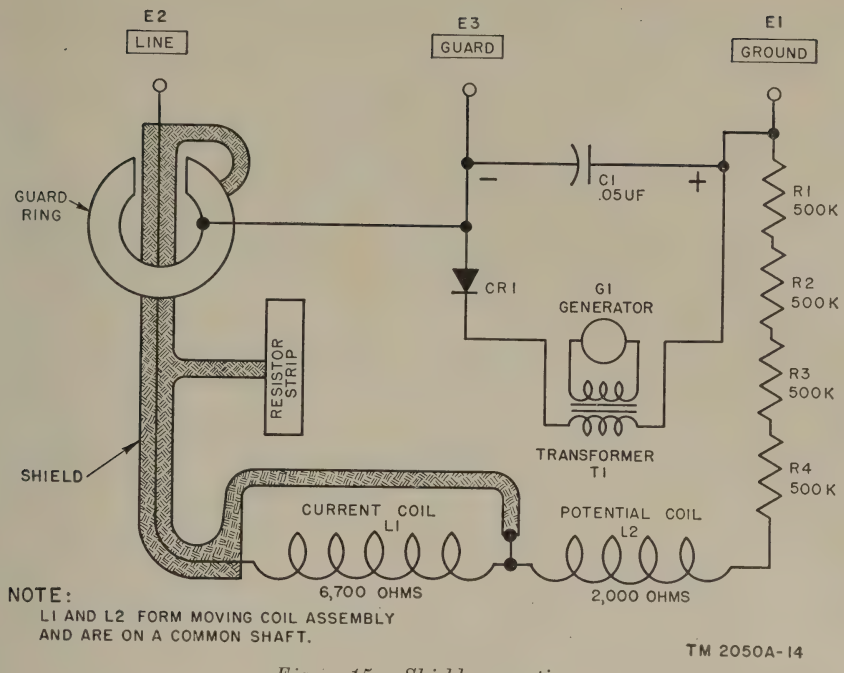

Figure 15. Shield connection.

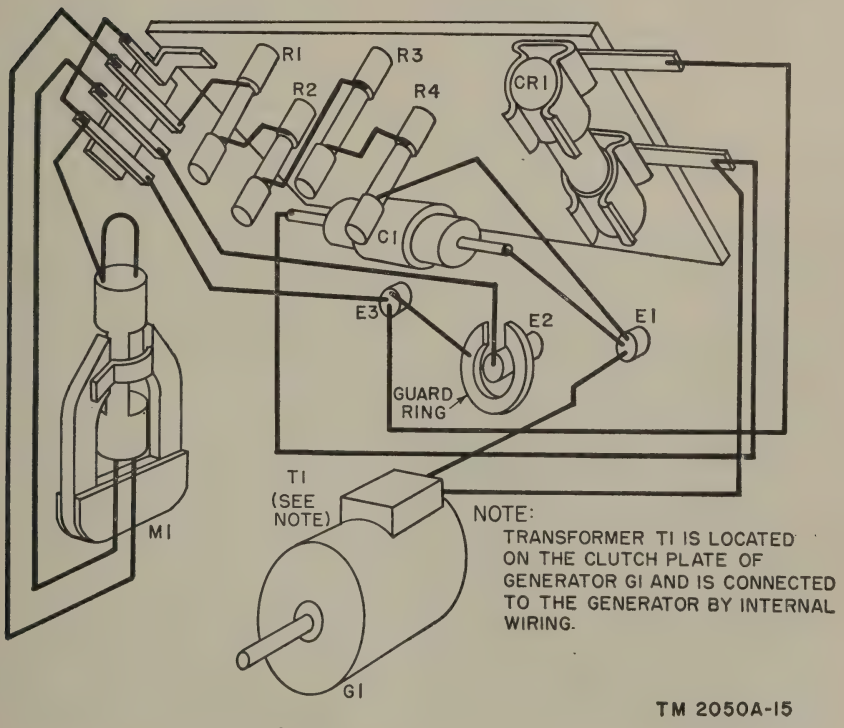

Figure 16. Wiring diagram.

CHAPTER 6
FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibilities is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. PREREPAIR PROCEDURES

49. Tools, Materials, and Test Equipment

In addition to the materials listed in paragraph 32, the tools, materials, and test equipment required for reconditioning, adjusting, and repairing Ohmmeter ZM–21/U are listed in *a* and *b* below.

a. Tools and Materials.

Sig C stock No.	Name and description of item	Used to
6Z2000	Cloth, crocus: 9″ x 11″	Clean commutator.*
6N228–3	Compass, drafting	Mark blank meter scale.
6M614	Ink: India; black	Letter blank meter scale.
6G242	Insulating compound	Caulk meter scale cover.
6Z7515	Pegwood	Clean jewels in meter bearing.
6M1101	Pen, ruling	Letter blank meter scale.
6Z7517	Pithwood	Clean meter pivots.
6RK19040.1	Screwdriver: jewelers set	Adjust meter jewels.
6N7531	Solder M–31	Resolder equipment wiring.
6R24617	Soldering Iron TL–117	Resolder equipment wiring.

*After using crocus cloth, clean the commutator thoroughly with carbon tetrachloride.

b. Test Equipment.

Sig C stock No.	Name and description of item	Used to
3F43256505	Electronic Multimeter TS–505/U: general purpose ac and dc vacuum-tube voltmeter; ranges .05 to 1,000 volts dc, .05 to 200 volts ac, and 1 ohm to 1,000 megohms. (Refer to TM 11-5511.)	Make voltage output and resistance tests.

50. Removal of Chassis and Chassis Cover To Permit Inspection

a. Remove the four screws that hold the end shield and the attached chassis to the equipment case.

b. Extend the hand generator crank until it is at right angles to the end shield. Grasp the crank and withdraw the end shield and the chassis from the case. Be careful not to damage the meter pointer or the wiring to the equipment terminals.

51. Inspecting and Cleaning Chassis Assembly

a. Inspecting. When the ohmmeter is turned in for repair, and the cause of trouble is not immediately apparent, make a preliminary inspection of equipment to determine the extent of repair necessary. Refer to figures 16, 17 and 20 for location of parts:

(1) Inspect the wiring for broken leads and brittle insulation. Inspect for broken insulation connections to terminals and other parts, and for defective soldered connections. Examine for bare wires touching other wires or the chassis.

(2) Test the operation of the hand generator by turning the crank a number of times. The shaft should move freely and smoothly without binding.

(3) Inspect for loose or missing screws.

(4) If there is no indication of damage or fault, operate the unit according to the procedure given in paragraph 42 to see if the test set is operating properly.

b. Cleaning.

(1) Clean the outside of the equipment with a clean, lint-free cloth.

(2) Remove dirt and salt spray from the exterior of the case with a cloth moistened in clear water. Allow the equipment to dry thoroughly before attempting any further cleaning.

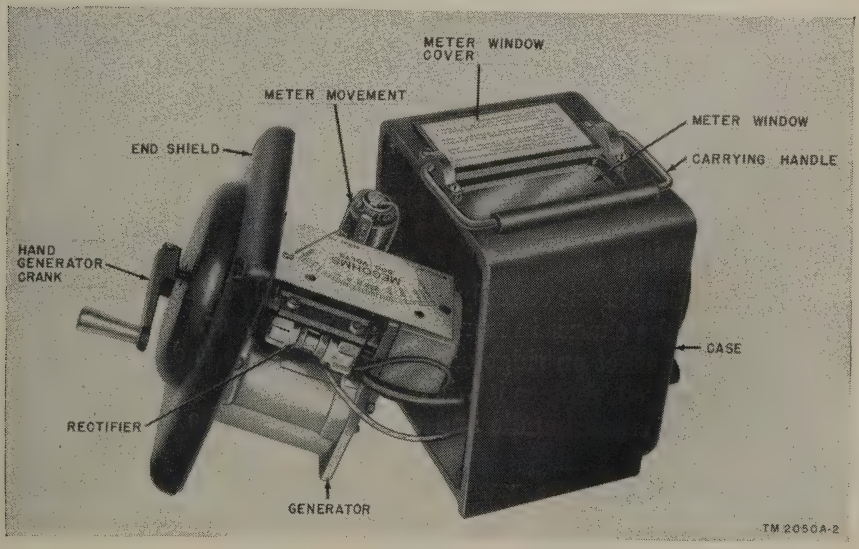

Figure 17. End shield and housing.

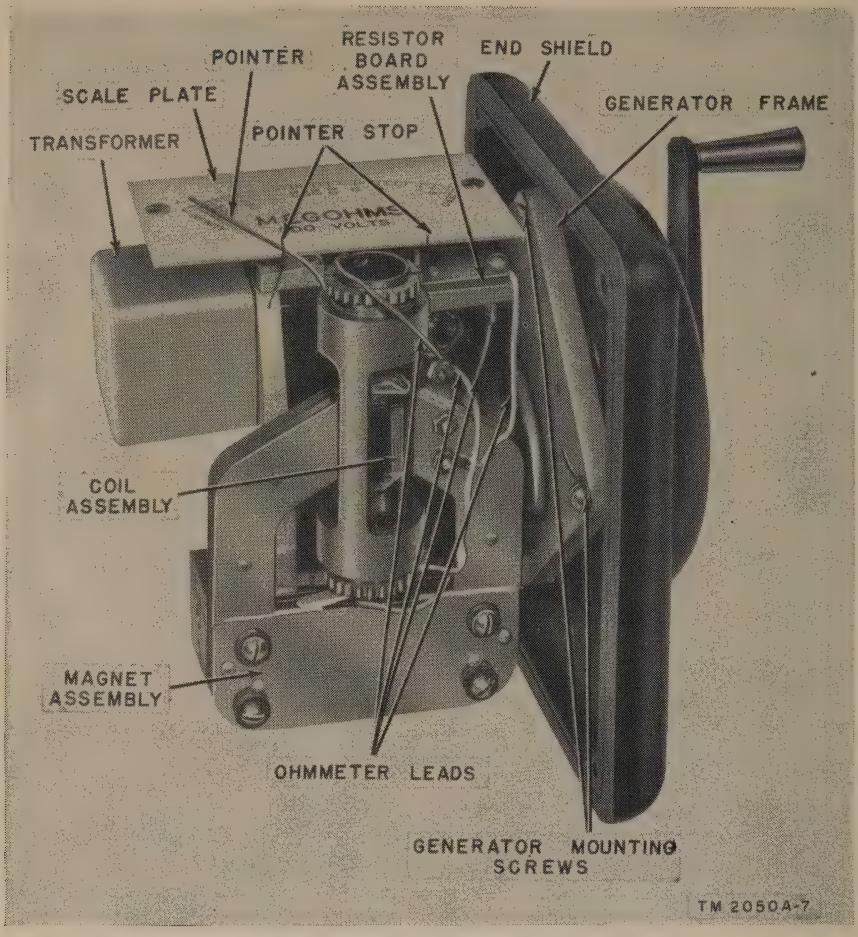

Figure 18. End shield and chassis.

(3) Brush the accumulated carbon dust from the interior of the case with a soft bristled brush. Be careful not to damage the equipment wiring.

(4) Remove oil and grease with a cloth moistened with solvent (SD). Wipe dry with a clean, dry cloth.

52. Reassembling Equipment

a. Replace the chassis cover by pushing it gently into place. Replace the screws on the chassis in front of the chassis cover.

b. Seat the gasket on ridge on inside face of the end shield. If the gasket is damaged, replace it with a new one.

c. Grasp the crank handle and carefully insert the chassis into the case.

d. Replace the four screws on the end shield and tighten them securely.

Section II. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

53. Troubleshooting

The function of troubleshooting is to locate and remove faulty operation quickly. Operational difficulties have definite symptoms which serve as clues to the cause of the trouble. The chart in paragraph 55 indicates various troubles that may be experienced, probable causes, and suggested remedies. The tests in paragraph 56 give the repairman the procedures to follow to isolate the probable cause of trouble.

54. Troubleshooting Data

Before proceeding with the actual location of trouble, a knowledge of the functioning of the ohmmeter and the theory of operation is necessary. The detailed functioning of the ohmmeter is covered in paragraphs 43 through 48. The troubleshooting chart (par. 55) should be used as a reference when attempting to locate trouble in the equipment. To supplement the theory of operation and to locate parts, refer to the following illustrations:

a. Complete schematic diagram (fig. 14).
b. Functional diagram (fig. 15).
c. Block diagram (fig. 12).
d. Illustrations showing locations of parts (figs. 2, 13, 17, 18 and 20).

55. Troubleshooting Chart

Symptom	Probable cause	Correction
Meter will not indicate ZERO with GROUND terminal E1 and LINE terminal E2 connected together.	Defective resistor.	Replace resistor.
	Loose connection to LINE or GROUND terminal.	Resolder connection.
	Loose connection to meter terminal.	Resolder connection.
	Loose connection or broken wire to generator.	Repair connection or replace wire.
	Defective meter armature.	Replace armature (par. 62).
Meter will not indicate INFINITY with no connections to terminals.	Defective resistor.	Replace resistor.
	Loose connection to meter terminal.	Resolder connection.
	Loose connection or broken wire to generator.	Repair connection or replace wire.
	Defective meter armature.	Replace armature (par. 62).
Meter indication incorrect when testing known resistance.	Defective resistor R1, R2, R3, or R4.	Replace resistor.
	Defective meter armature.	Replace armature (par. 62).
Generator voltage low.	Loose clutch adjustment.	Tighten clutch (par. 70).
	Defective or worn generator brushes.	Replace brushes (par. 62).
	Defective generator armature.	Replace armature (par. 62).
Generator voltage high.	Tight clutch adjustment.	Loosen clutch (par. 73).

56. Troubleshooting Procedures

a. Indicator Scale Test. The indicator scale test may localize a faulty meter reading to the indicating instrument. Proceed as follows:

(1) Connect the LINE and GROUND terminals to known resistances.

(2) Operate the hand generator crank. Note any deviation between the known resistance values and the values shown on the indicator scale of the test set.

(3) The deviation from any marked point on the scale should not exceed one thirty-second of an inch.

b. Output Voltage Test. The output voltage test may show that the generator is defective or that the clutch needs adjustment. Proceed as follows:

(1) Connect Electronic Multimeter TS–505/U to the GROUND and GUARD terminals.
(2) Turn the hand generator crank until the clutch slips. Note the output voltage.
(3) The output voltage of the generator should be between 500 and 525 volts dc. If the multimeter reading is below 500 volts or above 525 volts adjust the clutch according to directions in paragraph 70*e*.

Note. Low output voltage that cannot be adjusted may be caused by an open current coil in the indicating instrument.

c. Resistance Network Test. Disconnect the four resistors and check each separately with Electronic Multimeter TS–505/U. The resistors should check within 1 percent of their marked values. Normal resistance values are given in figure 14.

d. Continuity Test. Check the continuity of the circuit, point-to-point, with Electronic Multimeter TS–505/U. Check for possible short circuits in the same manner.

e. Intermittent Trouble. Do not overlook the possibility of an intermittent trouble. If an intermittent trouble is suspected, try to make it appear by jarring or tapping the equipment.

Section III. REPAIRS

57. Replacement of Parts

Only competent personnel supplied with adequate tools and equipment are authorized to repair Ohmmeter ZM–21/U. All parts can be reached easily for replacement by removing the chassis assembly from the case. When removing wiring from terminals, either by unsoldering or by loosening screw-type terminals, tag each wire to facilitate correct wiring when a new part is installed. Be careful not to damage adjacent parts when removing, installing, and connecting new parts. Any replacement part should be identical with the original and installed in the same physical position as the part that it replaces. When replacing wiring, be sure that each new piece of wire is the same length as the wire being replaced.

58. Replacement of Meter

a. Remove the chassis from the bakelite case according to directions in paragraph 50. Be careful not to break the flexible leads to the test set terminals.

b. Unsolder the connections to the meter bifilar suspensions (fig. 18). Tag each wire so that it may be replaced properly.

c. Remove the mounting screws and bushings from the meter magnet and remove the meter.

d. Install a new meter, using the same screws and bushings which were used to mount the old instrument. Resolder the equipment wiring to the meter terminals.

e. Replace the meter scale plate (fig. 19) with a blank scale plate. Calibrate and mark the new meter scale plate in accordance with directions in paragraph 69.

59. Replacement of Transformer

Remove the chassis from the case as instructed in paragraph 50 and proceed as follows:

a. Disconnect one transformer lead from GROUND binding post E1 and the other lead from the rectifier CR1 mounting.

b. Remove the screws which hold the transformer to the generator clutch plate.

c. Unsolder the two transformer leads to the generator unit.

d. Replace the transformer. Be sure to connect the leads of the new transformer to the correct terminals.

60. Replacement of Hand Generator

Remove the chassis from the bakelite case in accordance with directions in paragraph 50. All parts are mounted on the generator frame and must be removed before the generator unit is replaced. Proceed as follows:

a. Remove the ohmmeter as outlined in paragraph 58.

b. Remove the meter scale plate.

c. Remove the transformer as instructed in paragraph 59.

d. Remove the resistor board assembly (fig. 18) mounted on top of the generator frame.

e. Remove the setscrew from the crank and remove the crank from the generator drive shaft.

f. Remove the cover from the under side of the generator.

g. Remove the mounting screws (fig. 18) which hold the generator frame to the end shield.

h. Remove the old generator unit.

i. Install the new generator unit, using the same mounting screws.

j. Remount all the parts that were removed from the generator frame. Be sure to replace the parts in an order opposite to that in which they were removed.

k. Replace the generator crank.

61. Replacement of Rectifier

Remove the rectifier from its mounting bracket and snap the new rectifier in place. Be sure, however, that the new rectifier is polarized correctly. One end of the rectifier and one end of the mounting are marked; the marked ends must coincide.

62. Replacement of Hand Generator Armature

a. Remove the generator in accordance with directions in paragraph 63*a* through *c*.

b. Remove the generator brush caps and remove the brushes.

c. Remove the two self-locking nuts at the front end of the generator.

d. Withdraw the armature and replace it with a new one.

e. Place the end bell in position and replace the self-locking nuts.

f. Replace the generator brushes and brush caps.

g. Reinstall the generator as instructed in paragraph 60*g* and *h*.

63. Replacement of Terminals

When replacing terminals, be very careful to install all washers and insulator bushings in the same order in which they were originally installed. Observe this precaution especially in the case of the LINE terminals. This is the terminal on which the guard ring is mounted.

64. Replacement of Meter Window Glass

a. Remove the rectangular nickel-plated bezel from the top surface of the meter window (fig. 2).

b. Lift out the old meter window glass and clean away old insulating compound from around the meter scale aperture.

c. Place new insulating compound around the scale aperture and press the new meter window glass in place.

d. Press the bezel down firmly over the glass.

65. Replacement of Meter Window Cover

a. Remove the four screws that hold the pillow blocks in place (fig. 2).

b. Lift off the pillow blocks. Lift the old cover out of the recess above the meter window into which it fits.

c. Install a new cover and replace the pillow blocks.

66. Lubrication of Ohmmeter at Field Maintenance Level

a. General. The generator ball bearings and the drive assembly gear train are lubricated by the manufacturer and ordinarily will require no further lubrication. When the generator is disassembled for repair, however, lubricate these parts in accordance with instructions in *c* below.

b. Disassembly.

(1) Remove the chassis and chassis cover (par. 50) and inspect and clean the chassis assembly as instructed in paragraph 51.

(2) Clean all parts to be lubricated with a clean, soft brush or a clean, lint-free cloth dampened with cleaning compound.

c. Lubrication. Apply a small amount of Grease, Aircraft and Instruments (GL) (QMC supply No. 14–G–160–900) to the generator

ball bearings and the entire drive assembly gear train with the tip of a finger. Wipe off excess lubricant with a clean, lint-free cloth. Grease (GL) is an all-weather grease. No special precautions are necessary when this lubricant is used in arctic climates. The grease also is satisfactory for use in high desert and tropical temperatures.

67. Refinishing

a. Refinishing procedures apply only to the carrying cases of Ohmmeter ZM–21/U. The molded plastic instrument case cannot be refinished. When painted finishes have been badly marred, retouch the surfaces if the bare parts are restricted to small areas, but refinish the entire case if the damaged areas are large.

b. Use No. 000 sandpaper to clean the surface down to the bare metal or wood. Refinish affected surfaces to match the original finish, applying one coat of enamel or paint. Use authorized paint, consistent with existing regulations.

Section IV. CALIBRATION AND ADJUSTMENT

68. Equipment Required for Calibration of Meter Scale

In addition to Electronic Multimeter TS–505/U (par. 49*b*), the following equipment is required for calibrating the meter scale:

a. Ten resistors, .1 megohm ±1 percent (Sig C stock No. 3Z6700–31).

b. Ten resistors, 1 megohm ±1 percent (Sig C stock No. 3Z67801–95).

c. Ten resistors, 10 megohms ±1 percent (Sig C stock No. 3Z6810–31).

d. Ten resistors, 100 megohms ±1 percent (Sig C stock No. 3Z6901).

69. Calibrating and Marking of Meter Scale

Note. Before calibrating a new meter scale, check the output voltage of the ohmmeter (par. 56*b*). If the output voltage is above 525 volts or below 500 volts adjust the clutch as instructed in paragraph 70.

a. Calibrating. To calibrate a blank meter scale, proceed as follows:

(1) Connect the LINE and GROUND terminals together and turn the hand generator crank at operating speed. The meter pointer should deflect to the right-hand end of the blank scale plate. This point is the ZERO calibration on the scale; mark this point in pencil.

(2) Remove the connector between the LINE and GROUND terminals of the ohmmeter and again turn the hand generator crank at operating speed. The pointer should deflect to the opposite end of the blank scale plate. This is the INFINITY point on the scale; mark this point in pencil.

(3) Connect resistors (par. 68), singly or in series, to obtain the various values of resistance such as were indicated on the original scale (fig. 19). Connect the resistors between the LINE and GROUND terminals of the ohmmeter. Each time, turn the hand generator crank at operating speed. Mark each resistance value on the blank scale plate in pencil.

b. Marking. Remove the meter scale plate from its bracket and draw in the new points of calibration with India ink. Use a straightedge and a draftsman's ruling pen. Letter the resistance values on the scale with a LeRoy lettering pen.

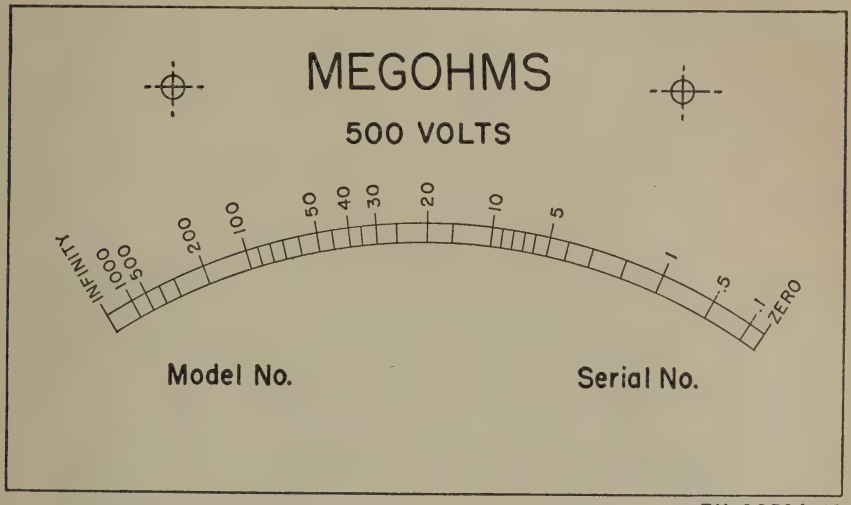

Figure 19. Meter scale.

70. Adjustment of Clutch

The clutch adjustment controls the slip-speed of the hand generator which, in turn, controls the output voltage of the generator. The clutch in a properly adjusted instrument slips when the generator is rotating at a speed fast enough to develop between 500 and 525 volts. To adjust the clutch slip, vary the pressure exerted upon the clutch drive hub and the clutch driven hub as follows:

a. Remove the chassis (par. 50).

b. Connect Electronic Multimeter TS–505/U between the GROUND and GUARD terminals.

c. Turn the hand generator crank, and when the clutch slips, note the output voltage.

d. If the output voltage is below 500 volts, raise the slip-speed of the clutch as follows:

(1) Using the $\frac{5}{64}$-inch Allen type wrench, turn the three countersunk screws on the clutch plate (fig. 20) counterclockwise, equally, a minute amount.

(2) Using the ⅛-inch Allen type wrench, turn the three protruding screws clockwise until they are tight.

(3) Measure the output voltage. If the voltage is still below 500 volts, repeat the adjustments in (1) and (2) above until an output of 500 volts has been obtained.

e. If the output voltage is above 525 volts, lower the slip-speed of the clutch as follows:

(1) Using the ⅛-inch Allen type wrench, turn the three protruding screws on the clutch plate counterclockwise, equally, a minute amount.

(2) Using the 5/64-inch Allen type wrench, turn the three countersunk screws clockwise until they are tight.

(3) Measure the output voltage. If the voltage is still above 525 volts, repeat the adjustments in (1) and (2) above until an output voltage in the 500- to 525-volt range has been obtained.

Caution: When adjusting the clutch plate, be very careful to tighten or loosen each screw in each group by the same amount.

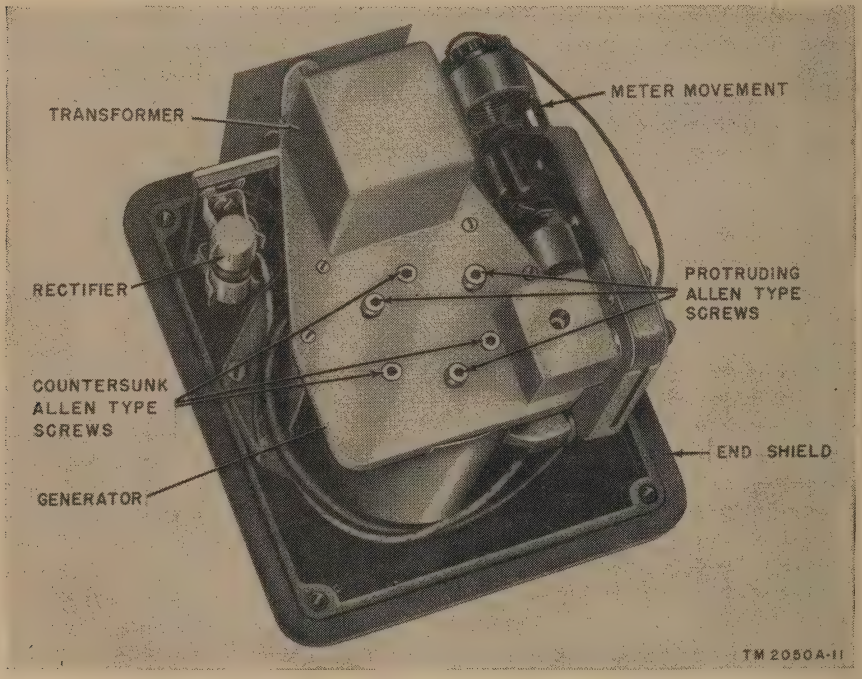

Figure 20. Chassis, rear view.

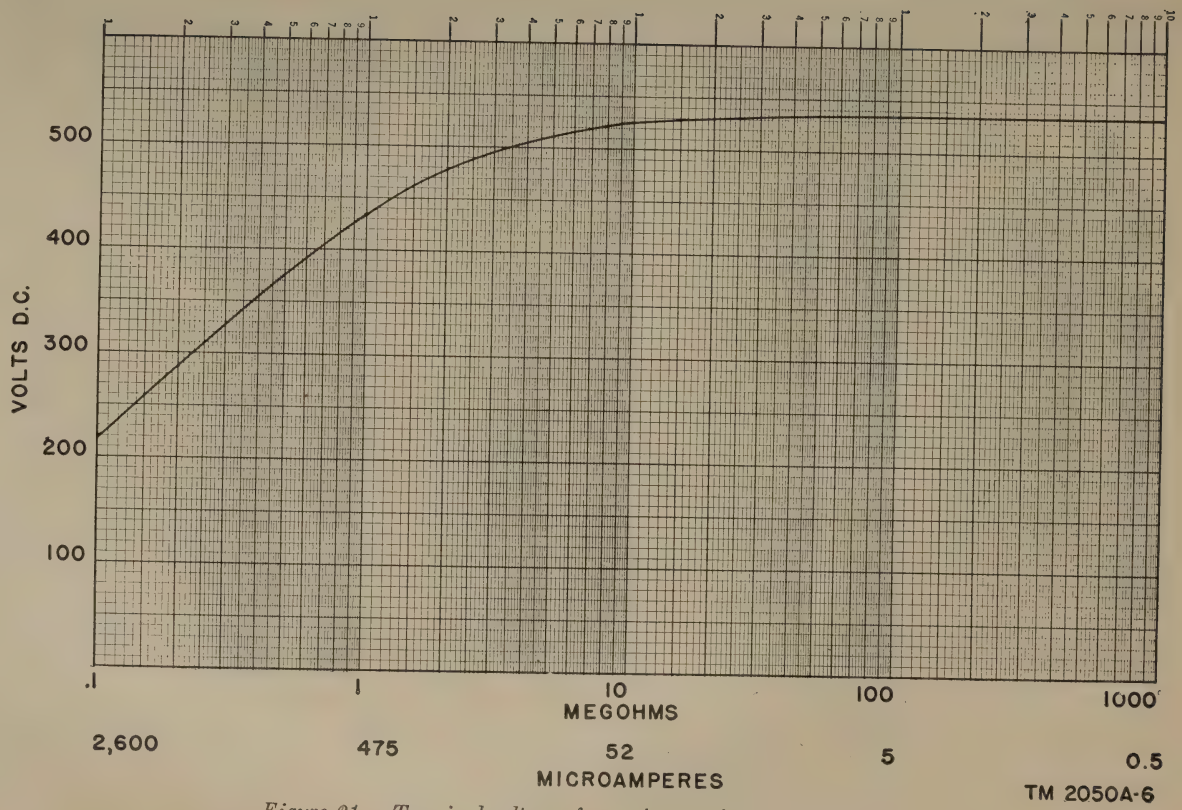

Figure 21. Terminal voltages for various resistances under test.

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

71. Removing from Service

a. Remove all test leads from the ohmmeter terminals; coil and tie the leads.

b. Close the meter scale cover.

c. Fold the generator crank handle to its nonoperating position.

d. Remove the webbed strap from the carrying case, coil it, and tie it with cotton tape.

e. Place the test leads in the compartment provided for them in the carrying case of Ohmmeter ZM–21/U. Place the coiled strap in the test lead compartment.

f. Place the technical manuals in the holder in the carrying case cover.

g. Place the ohmmeter in the carrying case; close and latch the cover.

72. Repacking

Note. The circumstances involved in shipment and storage vary. The following instructions are recommended as a guide for preparing Ohmmeter ZM–21/U for transportation and storage. Whenever possible, use the original packaging materials.

a. Cushion the cased ohmmeter on all surfaces with cells and/or pads fabricated of corrugated fiberboard. This will absorb the shock of impact normally encountered in handling and during transit.

b. If possible, place a dehydrating agent, such as silica gel, inside the cells of corrugated fiberboard.

c. Place the cushioned equipment in a close-fitting corrugated fiberboard box. Seal the entire closure with gummed paper tape. Blunt the corners of the box.

d. Place the boxed equipment in a water-vaporproof barrier. Extract the air and heat-seal the barrier.

e. Place the barrier-wrapped box in a second close-fitting corrugated fiberboard box. Seal the box with water-resistant tape or adhesive.

73. Methods of Destruction

The demolition procedures outlined below will be used to prevent the enemy from using or salvaging the equipment. Demolition of the equipment will be accomplished only upon order of the commander.

a. Smash. Smash the meter window glass and break off the indicating needle. Smash the instrument case, chassis, meter, generator, binding posts, and carrying case; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or other heavy tools.

b. Cut. Cut test leads, wiring, and carrying strap; use axes, handaxes, or machetes.

c. Burn. Burn the carrying strap, technical manuals, and the carrying case; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

e. Disposal. Bury or scatter the destroyed parts in slit trenches, fox holes, or other holes, or throw them into streams.

f. Destroy. Destroy everything.

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By order of the Secretary of the Army:

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